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Sleep-disordered breathing and orthodontic variables in children—Pilot study☆

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ABSTRACT

Introduction: Sleep Disordered Breathing (SDB) is a highly prevalent condition associated with orofacial and dentofacial characteristics.
Objective: The aim of this study was to verify the association of dental malocclusion, molar relationship, crossbite, open bite, overjet, overbite, and crowding with SDB in children aged 7–9 years.
Materials and methods: Participating schools were selected randomly from within the public elementary school system. In the first phase of the study, the parents of 1216 children aged between 7 and 9 years old completed the Sleep Disturbance Scale for Children (SDSC) questionnaire and the children had to participate in a dental examination. The evaluation of occlusion was divided into sagittal analysis, vertical analysis, and transverse analysis. In the second phase, 60 children were selected randomly to be undergone polysomnography (PSG) at a sleep clinic.
Results: Among the children included, 242 (19.9%) children had normal occlusion. Of the 60 children, 50 underwent PSG and 40 (80%) had SDB. The crossbite and open bite showed association with SDB, $p = 0.04$ in both.
Conclusion: Crossbite and open bite malocclusions were associated with SDB, and may be predictive of SDB in children. Studies with larger numbers of participants are needed to investigate the association of other malocclusions with SDB, and randomized clinical trials are also needed to see whether orthodontic and/or functional jaw orthopedic treatment is an option for treating children with malocclusion and SDB.

1. Introduction

Respiratory problems, such as hypertrophic adenoids and tonsils, chronic and allergic rhinitis, nasal deformities, nasal trauma, polyps and tumors, and others are related to sleep-disordered breathing [1], dentofacial morphology and malocclusion in children [2].

SDB is common in children, and occurs at all ages, from the neonatal period to adolescence [3]. It is estimated that 0.8–24% of children are habitual snorers, and 1–5% have obstructive sleep apnea syndrome (OSAS) [4].

Malocclusion can be defined as any dental, skeletal, or dental–skeletal dysplasia [5] that causes an incorrect relationship between the upper and lower teeth. Malocclusion can affect mastication, swallowing, speech, and breathing, as well as quality of life, interpersonal relationships, self-esteem, and psychological well-being [6].

Untreated SDB has been associated with serious sequelae, such as cor pulmonale and failure to thrive [7], as well as behavioral, neurocognitive, and emotional issues, hyperactivity, attention deficit [8], and systemic inflammation [9]. If left untreated in childhood, it can contribute to the development or continuation of hyperactivity in adulthood [10]. Some studies have shown that snoring results in the symptoms of excessive daytime sleepiness, behavioral problems, and poor school performance [11].

SDB is a highly prevalent condition associated with orofacial and dentofacial characteristics [12,13]. The dentofacial features

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most commonly found in patients with SDB are retrognathia or micrognathia, unilateral or bilateral crossbite, open bite or deep overbite, increased overjet, narrow upper arch, and short lower jaw [12–15]. Orofacial characteristics include triangular chin, mandibular retroposition, steep mandibular plane, deep hard palate, soft palate, and long oval face [16].

The aim of this study was to verify the association of dental malocclusion, molar relationship, crossbite, open bite, overjet, overbite, and crowding with SDB in children aged 7–9 years.

2. Materials and methods

2.1. Sample

This study was approved by the research ethics committee of the Universidade Federal de São Paulo # 1181/09 and carried out in the period May to December 2011 in Osasco city, state of São Paulo, Brazil. Participating schools were selected randomly from within the public elementary school system. In the first phase of the study, the parents of 1216 children aged between 7 and 9 years old completed the SDSC (Sleep Disturbance Scale for Children – validated to Brazilian Portuguese) [17] and the children had to participate in a dental examination. Participants were divided into three groups according to their score on the SDSC. The SDSC items used to detect symptoms of SDB were: (1) ''The child has difficulty in breathing during the night''; (2) ''The child gasps for breath or is unable to breathe during sleep''; and (3) ''The child snores''. Answers are given on a Likert scale of 1–5: 1 point for ''never'', 2 points for ''occasionally'' (once or twice per month), 3 points for ''sometimes'' (once or twice per week), 4 points for ''often'' (3–5 times per week), and 5 points for ''always'' (daily). Hence, the sum score for the three questions can be at least 3 and at most 15. According to the total score obtained for these three SDSC items, participants were divided into 3 groups: group 1, at high risk of SDB (12–15 points); group 2, at moderate risk of SDB (7–11 points); and group 3, at low risk of SDB (3–6 points).

In the second stage, 60 children, 20 from each group, were randomized to the PSG. Consent form was obtained from the parents or guardians of all children. We excluded children with developmental syndromes, cleft lip and/or palate, those who had undergone tonsil and/or adenoid surgery, and those who were under or had a history of orthodontic or functional jaw orthopedic treatment. The distribution of participants by gender, age, and body mass index [18] (BMI) is shown in Table 1.

Sixty children were called and agreed to take part in the second stage of the study, independently of the type of dental occlusion, which involved PSG at a sleep clinic, accompanied by a parent or guardian. Ten children failed to attend their appointments.

This project also had the consent of the Osasco municipal government, the Department of Education, and the principals, coordinators, and teachers of the municipal schools involved, and financial support from FAPESP (#2010/02633-2).

2.2. Procedure

On the scheduled date and time, the team, composed of two dentists (one examiner and one recorder) and a dental hygienist, went to each school with all the material needed to conduct the study. All participants were examined by the same dentist.

In order to verify the reliability of the observations of the examiner dentist, a previous study was done to check the variability and reproducibility of the malocclusions observations [19]. Cohen's kappa statistic was conducted to evaluate intra- and interobserver agreement in malocclusion diagnosis. Intraobserver agreement was strong for all variables and interobserver agreement was also strong, except for the variable overbite, which had good agreement [19].

The evaluation of occlusion was divided into sagittal analysis, vertical analysis, and transverse analysis [19,20]. All definitions of the types of occlusions evaluated and how was divided the analysis were described in another our paper [19].

The PSG was conducted using a computerized Alice 3 system (Healthdyne, Marietta, GA) in a sleep laboratory, which specializes in the care of children. The children were accompanied by their parents or guardians. No sedation or sleep inducer was used. The examination was carried out overnight.

Physiological parameters during the PSG were measured using: an electroencephalogram; an electromyogram (submental and bilateral tibial); an electrooculogram; an electrocardiogram; an oronasal thermistor for airflow; pulse oximeter for oxygen saturation (Sat O_2); a strap with a sensor for thoracic and abdominal movement; and a body position sensor. The assembly of the PSG and the criteria for the report met the parameters described in the American Academy of Sleep Medicine manual [21].

PSG was scored for sleep stages using 30-s epochs [21]. Respiratory events were scored according to standard criteria for children [22,23]. Obstructive apnea was defined as cessation of airflow, lasting for at least 2 breaths, in the presence of paradoxical ribcage and abdominal movements [21]. Hypopnea was defined as a reduction of the thermistor signal by more than 50% that was accompanied by either oxygen desaturation or arousal [21]. Central apnea was defined as the absence of airflow at both the nose and mouth with absent inspiratory effort throughout the entire duration of the event, lasting 20 s or longer, or 2 missed breaths accompanied by at least a 3% oxygen desaturation, an arousal, or an awakening [21]. The obstructive apnea index was defined as the number of obstructive apneas per hour of sleep [22,23]. The apnea–hypopnea index (AHI) was defined as the number of obstructive apneas and hypopneas per hour of sleep[22,23]. Snoring was defined as a loud breathing produced mainly by the vibration of the soft palate and oropharyngeal pillars. Based on polysomnography, snoring was determined to be absent or present and arousal was defined as minimum of duration of 3 s [24].

The children were monitored and audio and video recordings were made. Each child was continuously observed by a technician trained in pediatric PSG who also recorded behavior during sleep.

Table 1
The distribution of participants by gender, age, and BMI.

	Boys $n=26$			Girls $n=24$			Total $n=50$			Total
Age (years)	7	8	9	7	8	9	7	8	9	
Number of participants	10	15	1	11	8	5	21	23	6	50
BMI (SD)[a]	17.82 (±5.12)	18.95 (±5.10)	17.46	18.81 (±4.13)	18.24 (±3.48)	17.79 (±3.91)	18.16 (±4.52)	18.82 (±4.54)	17.73 (±3.50)	18.82 (±4.36)
Z score (SD)[a]	0.00 (±1)	−0.04 (±1)		0.08 (±1)	0.00 (±1)	0.00 (±1)	0.00 (±1)	0.00 (±1)	0.00 (±1)	0.00 (±1)

[a] BMI and *Z* score is expressed as mean and standard deviation (SD).

Table 2
The normal values of ArI, AHI, snoring, and Sat O_2 considered for polysomnographic parameters [21–27].

Variable polysomnographic	Normal values
Arousal index (ArI)	Less than 7
Apnea–hypopnea index (AHI)	Less than 1
Snoring	Absence of snoring
Oxygen saturation (Sat O2)	Greater than or equal to 92%

The neurophysiologist was always blinded to the type of occlusion of the participant.

2.3. Data analysis

To determine the association between each of malocclusions and SDB, the Fisher exact test was used.

The normal arousal index, apnea index, apnea-hypopnea index, snoring, and Sat O_2 values considered for polysomnographic parameters are shown in Table 2 [21–27]. Children who had at least one abnormal parameter were considered to have SDB.

3. Results

The study sample comprised 1216 children, 569 boys (46.8%) and 647 girls (53.2%). Regarding age, 326 children (26.81%) were 7 years old, 515 (42.35%) were 8 years old and 375 (30.84%) were 9 years old (Table 3).

Among the children included, 242 (19.9%) children had normal occlusion. The highest prevalence of malocclusion was found in molar relationship 50.8% (617 children), followed by crowding in 33.6% (409 children), overbite in 30.3% (369 children), overjet in 24.7% (300 children), crossbite in 24.4% (297 children) and open bite in 15.8% (192 children).

Among the 50 children who underwent PSG and 40 (80%) had SDB and 10 (20%) did not have SDB diagnosed by PSG, i.e. 10 presented all variables polysomnographic with normal values, 16 presented one variable with abnormal value, 17 presented two variables abnormal, 7 presented three variables abnormal and nobody presented all (4) parameters abnormal (Table 4). The distribution among children with SDB and malocclusions is shown in Table 5, and Graph 1 shows the distribution of the children by age and AHI.

Graph 2 shows the distribution of participants and relation among number of parameters abnormals in PSG (ArI, AHI, snoring and Sat O_2) and total score of SDSC (sum of 3 questions).

4. Discussion

The main finding of this study was the association of SDB with crossbite and open bite.

Many studies have demonstrated the influence of mouth breathing in facial morphology, and it can increase the potential for developing a vertical growth pattern and facilitate installation of malocclusions type open bite and crossbite [28–34]. So the result of this study links the bite open and cross bite with SDB and often these malocclusions are also related to mouth breathing, then we can conclude that oral breathing, SDB and open bite and crossbite may be interrelated [35,36]. Thus the professionals involved in the diagnosis of any such deviations from normality should be aware of this interrelation to make the correct treatment, involving respiratory and dental problems.

Furthermore, this study also provides data on the prevalence of malocclusion, from the perspective of sleep-disordered breathing, which is worthy of attention, because children with SDB who are not treated at this age can carry the condition into adulthood, with a major negative impact on health, increased healthcare expenditures, and impaired quality of life [37].

Several other studies also showed a significant association between crossbite [38–40] or open bite [41,42] and SDB.

The malocclusions chosen for the examination were based on the literature, however we could not find a relationship between all of them and SDB in children. This could be due to the small number of participants. We want to increase the number of participants in the future and have a definitive answer on the association between types of malocclusion and SDB. These findings are very important because there are ways to treat this malocclusion with orthodontic appliances that will treat not only the esthetics but functional problems and problems related to SDB.

In terms of the prevalence data, of the 1216 children assessed, we found 19.9% had normal occlusion and 80.1% had malocclusion. This result is consistent with other conducted in Brazil. One study in Camaragibe City with 173 children where the prevalence of normal occlusion was 17.9% and that of malocclusion 82.1% [43]. However, there was a higher prevalence of malocclusion in two other Brazilians studies, one in the city of Bauru City (88.53%) [44]

Table 3
Distribution of participants by age and sex.

Age 7		Age 8		Age 9		Overall	
M	F	M	F	M	F	M	F
157	169	259	256	153	222	569	647
12.92%	13.89%	21.31%	21.04%	12.59%	18.25%	46.82%	5318%
326		515		375		1216	
26.81%		42.35%		30.84%		(100%)	

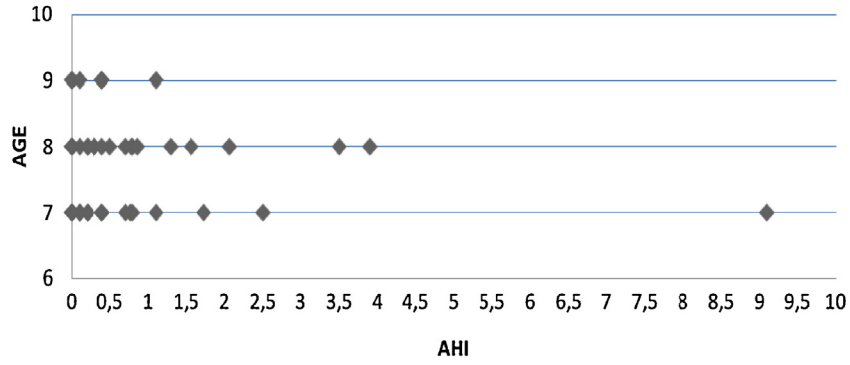
Table 4
Distribution of participants in polysomnographic variables according to the parameters used for normality.

Variable polysomnographic	Number of participants $n=50$	
	Normal values	Abnormal values
Arousal index[a] (normal value <7)	38	12
Apnea–hypopnea index[a] (normal value <1)	40	10
Snoring[a] (normal value – no snoring)	23	27
Oxygen saturation[a] (normal value ≥92)	28	22

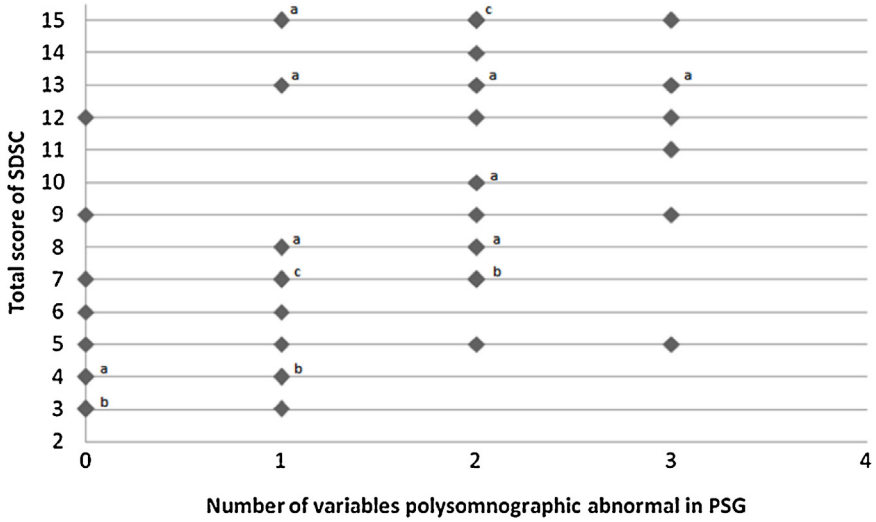
[a] Variables used to consider with or without SDB.

Table 5
The distribution among children with SDB and malocclusions.

Malocclusion		SDB				Total	p
		Absent		Present			
Molar relationship	Class I	6	24%	19	76%	25	0.72
	Class II	3	15%	17	85%	20	0.72
	Class III	1	20%	4	80%	5	0.99
Crossbite	Absent	10	26%	28	74%	38	0.04
	Present	0	–	12	100%	12	
Open bite	Absent	10	26%	28	74%	38	0.04
	Present	0	–	12	100%	12	
Overbite	Absent	5	15%	28	85%	33	0.27
	Present	5	29%	12	71%	17	
Overjet	Absent	9	24%	28	85%	37	0.19
	Present	1	8%	12	92%	13	
Crowding	Absent	5	16%	26	84%	31	0.47
	Present	5	26%	14	74%	19	



Graph 1. Distribution of participants by age and apnea–hypopnea index (AHI).



Graph 2. Distribution of participants by number of parameters abnormal in PSG. (ArI, AHI, snoring and Sat O2) and total score of SDSC (sum of 3 questions). ◆ = 1 participant; ◆[a] = 2 participants; ◆[b] = 3 participants; ◆[c] = 4 participants

and the other a multicenter study conducted in 18 Brazilian states (85.17%) [45].

When we compare this with other studies a higher prevalence of malocclusion is shown [46–48]. Our results are closer to those found in Iran [49] and Morocco [50], whose prevalence of malocclusion was 77.1% and 84.2% respectively. In all these studies, the prevalence was high, which seems to qualify dental malocclusion as a public health problem that deserves attention from health sectors.

Randomized controlled trials are necessary to verify whether orthodontic and/or functional jaw orthopedic treatment is effective for SDB in children [51].

Other studies are necessary to investigate the relationship between SDSC and diagnostic variables that comprise the PSG in children and determine the best cut-off point for the SDSC questionnaire to be useful as a screening test in SDB in children.

5. Conclusions

Crossbite and open bite malocclusions were associated with SDB, and may be indicative of SDB in children.

Studies with larger numbers of participants are needed to investigate the association of other malocclusions with SDB, and randomized clinical trials are also needed to see whether orthodontic and/or functional jaw orthopedic treatment is an option for treating children with malocclusion and SDB.

Conflict of interest

The authors declare that there is no conflict of interest.

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